KOCH

* * * * * * * * * *

Epidemiology of Tuberculosis

EPIDEMIOLOGY OF TUBERCULOSIS.

By Robert Koch.

(A lecture given before the Academy of Sciences of Berlin at its session of Apr. 7, 1910.)[1]

Investigations into the epidemiology of tuberculosis have brought out some facts of interest and also of practical importance which will be the subject of the present paper.

First some preliminary remarks concerning the character of the investigations. They are in all essential respects statistical. If attempt had been made to cover the entire field, insurmountable difficulties would have been encountered.

Tuberculosis, as is well known, manifests itself in the most varied ways, frequently occurring in such insignificant and latent forms that no sharp distinction can be made between those affected and healthy persons. For that reason it was necessary to limit the present discussion to a form that is sufficiently well marked and also diagnosed with certainty. These conditions are best fulfilled by tuberculosis of the lungs, the so-called pulmonary consumption. This form is also to be recommended for such investigations because it is by far the most frequent, the one chiefly concerned in disseminating tuberculosis and therefore the most important in medical practice.

A still further limitation must be made. Owing to the long duration of pulmonary consumption and the difficulty of making sharp distinctions as to its beginning, we must disregard the statistics of illness from this disease and consider only the statistics of death. In these we have original data that are, to a certain extent, trustworthy, and that may serve as a basis for investigation.

It is true that this trustworthiness could only be absolutely assured if in every case of death by pulmonary consumption the diagnosis were confirmed by an autopsy made by a competent expert,

[1] According to a manuscript kindly placed at the disposal of the editor of the Zeitschrift für Hygiene und Infections-krankheiten after the death of the author. Translated from Zeitschrift für Hygiene, Leipzig, 1910, vol. 67, Part 1, pp. 1–18.

which by no means really occurs. Autopsies are held only in a small proportion of cases, and therefore some uncertainty exists. Besides this, in many regions, even in entire countries, there is, for well-recognized reasons, a certain hesitation attached to pronouncing a diagnosis of pulmonary consumption, and the disease is called instead chronic catarrh of the lungs, or something similar. It is, therefore, not always admissible to compare with each other the death rates of pulmonary consumption of different countries without further examination, and it is to be supposed that many cases of striking differences may be explained by circumstances of this kind. This source of error has, however, no essential influence when we consider the increase or decrease of mortality in the same country or city.

On the other hand, it may be said that pulmonary consumption is a very satisfactory subject for statistical investigation, because its characteristic symptoms make its diagnosis quite certain, even by the laity, so that for many matters where absolute exactitude is not required, data are available, even though not supported by medical authority or by autopsies.

If in an investigation of the epidemiology of tuberculosis we go back to early data concerning mortality from consumption, we find the disease mentioned in the oldest records.

In the writings of Hippocrates a very characteristic description of pulmonary consumption is given, and we may conclude from it with certainty that the physicians of that time were quite familiar with the symptoms of the disease. It is stated in several places that numerous persons have been affected by it.[1] We must therefore conclude that phthisis already at that time played a part similar to that which it assumes at the present day.

We find the first numerical data, however, much later, and these relate to Sweden, where they were collected by the clergy.

From these we obtain the highest figures which mortality from phthisis has hitherto reached (Table 1). About the middle of the eighteenth century the mortality in Sweden was, for the country, 21.5 per 10,000 persons, and it rose very slowly to 27.7 about 1830.

[1] From the writings of Hippocrates (Grimm's translation). On Epidemics, p. 16: "For consumption alone, as the most important single disease among those prevailing at that time, killed many people"; p. 57: "The greatest and most terrible disease, and the one which was the most fatal, was pulmonary consumption."

TABLE 1.—*Mortality from pulmonary consumption.*

[After Sundbarg. Calculated for every 10,000 persons.]

	In Sweden.	In Stockholm.
1751–1760	21.5	73.2
1761–1770	20.6	69.8
1771–1780	20.8	74.4
1781–1790	23.1	87.7
1791–1800	24.0	85.0
1801–1810	25.1	83.7
1811–1820	26.9	87.2
1821–1830	27.7	93.1
1831–1860	(a)	(a)
1861–1870	30.6	43.3
1871–1880	32.4	40.6
1881–1890	30.0	34.6
1891–1900	27.0	29.2

[a] No data given.

Considerably higher figures prevail in the chief city of the country, and this corresponds to the usually accepted opinion that the cities, on account of the crowded buildings and the bad dwelling conditions connected therewith and also because of the less resisting power of their inhabitants, are more unfavorably situated as regards tuberculosis than is the open country. Stockholm had in 1750 a mortality of 73.2, which in 1830 had advanced to 93.1; that is to say, nearly 100 per 10,000, or 1 per cent.

The increase of mortality from phthisis in Stockholm is said by the Swedish physicians to be caused by the misuse of alcohol. The rate of 100 per 10,000 is only met with where the most unfavorable sanitary conditions are encountered, for example, in jails, at least in former times; and also among the perishing races of North American Indians where alcohol is also the principal cause of decay. According to the concurrent testimony of various travelers, the inhabitants of Greenland, compelled by the northern climate to live crowded together in their huts, thus greatly increasing the possibility of infection, suffer in an extraordinary degree from tuberculosis, reaching, it appears, even a higher figure than 100 per 10,000.

A death rate of 50 per 10,000 occurs rather frequently in the last quarter of the nineteenth century, especially in cities. I will cite as examples among the German cities: Düsseldorf, 55; Elberfeld, 59; Osnabrück, 52; Cologne, 50½; Munich, 50. Especially high figures occur in Austria-Hungary where there is 50 for Buda-Pesth; 58 for Presburg; 66 for Fiume; 72 for Vienna.

From these figures we have a gradual descent until we reach a total absence of mortality. In certain regions, as in central Africa, tuber-

culosis occurs only in quite isolated cases, the patients being of European or coast origin. At the present time the lowest figure for some regions in Australia is about 7 deaths per 10,000. But this figure is also reached in some sections of our own country, as for example, in the district of Osterode in the Province of Allenstein.

Such low death rates have only been observed during the last few years, and this leads me to the most notable phenomenon in the epidemiology of tuberculosis, to which I would especially invite your attention, namely, the almost universal marked decrease in pulmonary consumption which has become evident during the last 30 or 40 years.

The lowering of the death rate began first in England, and it also happened that the English hygienist Farr was the first who was struck by this and who called attention to it. In our own country Hirsch, the author of the well-known Handbook of Historico-geographical Pathology, was the first to mention it.

This remarkable phenomenon was at first received with great scepticism, and it was alleged that there were either errors in the statistics or that it depended upon the decrease in the general death rate which had been previously noted, though not to the same degree. But as the decrease in pulmonary consumption was shown to occur almost universally and also continued, there remained nothing to do but to acknowledge it as a fact and to find an explanation therefor.

In order to give an idea of the decrease of consumption, the course of the death rate from that disease in the Kingdom of Prussia may serve as a specially characteristic example.

It is shown graphically by a curve in Table 2. Up to the year 1886 the figures representing the mortality remain with irregular, but not marked variations a little above 30, then begins a decrease which has kept up with but little variation to the present time. In the year 1908 the figure fell to 16.24, a decrease of nearly 50 per cent.

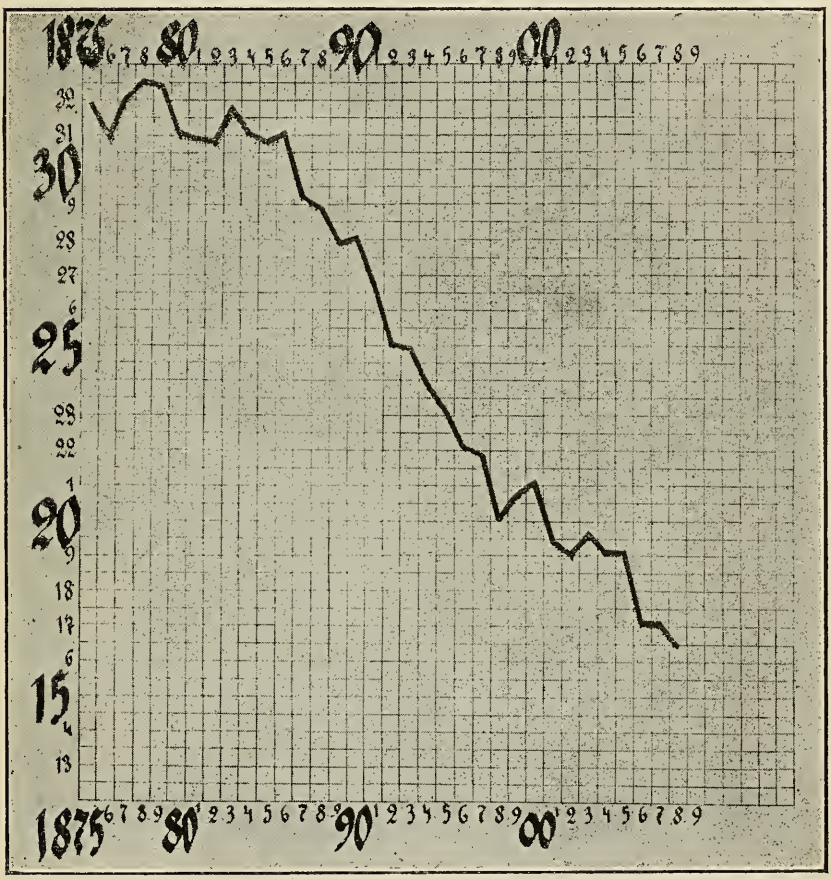
For the German Empire the statistical records do not go back far enough to demonstrate the reduction in consumption in a similar manner. Yet the curve for all Germany resembles, as far as it goes, that for Prussia; it is somewhat higher, because the States of southern Germany are not as favorably situated as Prussia with regard to the disease.

The significance of this reduction in consumption will be noted when we observe that if the same relations prevailed now as 30 years ago about 100,000 more persons would die annually of consumption than is now actually the case. It is therefore very important for us to ascertain the causes for this decrease, in order to know whether it is subject to any influence under our control; whether it would be possible, were it arrested, to overcome the obstacle, also whether it would be practicable to hasten its decline beyond the present rate.

The question, therefore, arises as to what is the cause, or rather what are the causes of this decrease, for it can hardly be supposed that it depends on a single factor alone.

Concerning this it might at first be supposed that the death rate from consumption decreases because the general death rate, as is well known, is also decreasing. This need not necessarily be so, for it would only occur in case the causes which influence the general death

TABLE 2.—*Mortality from consumption in Prussia.*



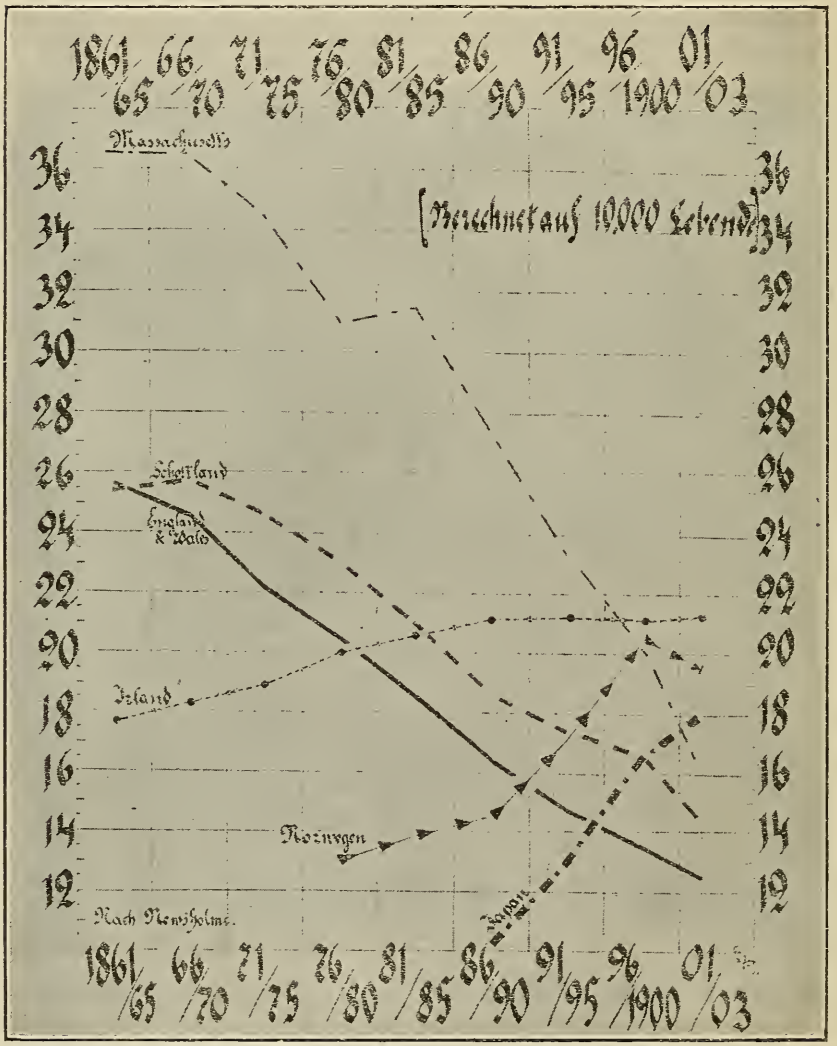
rate have a similar influence upon the death rate from consumption. But we now see that the decrease in the latter is much more rapid than that of the general mortality, this being more probably influenced in a considerable degree by the decrease in pulmonary consumption. Therefore that disorder must be influenced by factors peculiar to itself.

It might also appear possible that the decrease in tuberculosis depends upon the general epidemiological course of this disease; that

this epidemic in itself, like other epidemics, such as the plague and cholera, must decrease after a certain lapse of time.

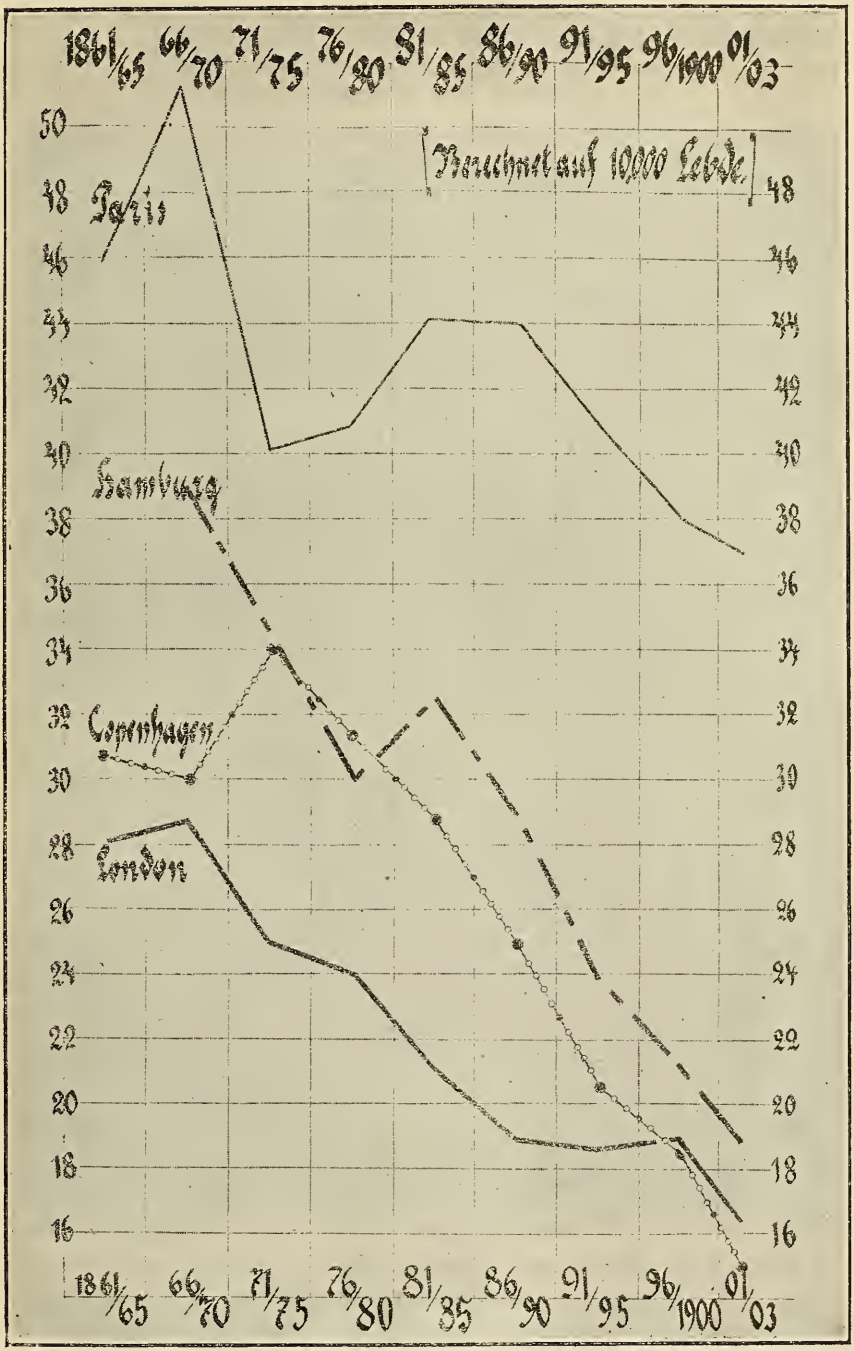
If this were its natural course then the decrease would proceed everywhere in a uniform manner. But this is by no means the case.

TABLE 3.—*Mortality from consumption in Massachusetts, Japan, Great Britain, and Norway.*



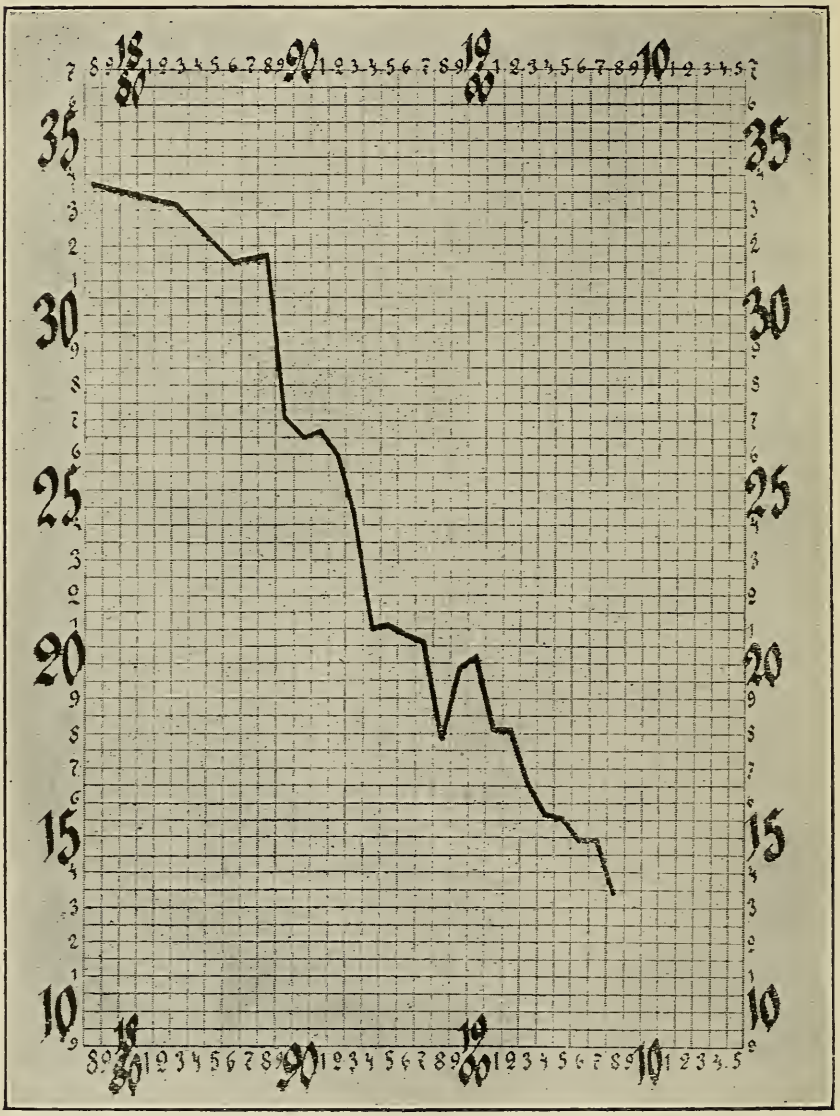
In most countries, it is true, the curve descends, but there are others in which it rises. It will be seen by consulting Table 3 that England, Scotland, and the American State of Massachusetts (chosen because its statistics reach far enough back) have a decreasing death rate from consumption, while in Ireland, Norway, and Japan it is increas-

TABLE 4.—*Mortality from consumption at Paris, Hamburg, Copenhagen, and London.*



ing. We meet with the same phenomenon in certain cities; so London, Copenhagen, and Hamburg have curves of decrease, while Paris, on the contrary, has a high-lying curve which shows but little tendency to descend (Table 4).

TABLE 5.—*Mortality from consumption at Hamburg.*



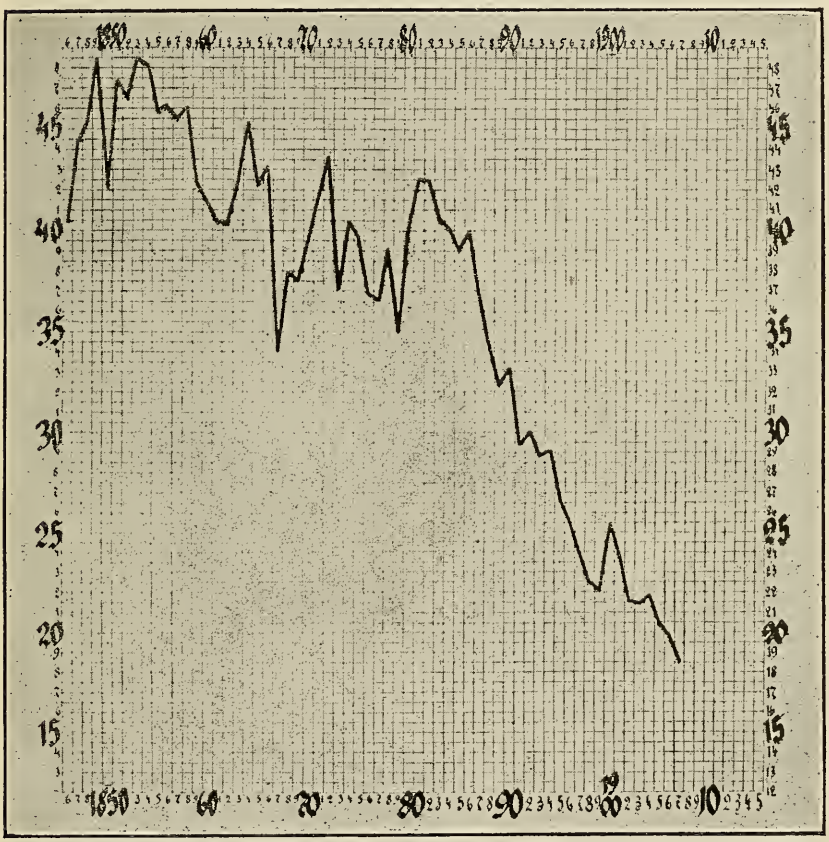
France has a death rate from consumption that is especially unfavorable. In cities of more than 5,000 inhabitants, the only ones for which statistics are available, 27 out of every 10,000 persons die of this disease, and there was no decrease in the years from 1901 to 1906 (so far as the data have been published).

Very characteristic examples of favorable indications in the mortality of consumption are shown by Hamburg (Table 5) and Boston (Table 6).

Before 1860 Hamburg lost by consumption 37 for every 10,000 inhabitants, and in 1880 the figure stood at 33.5. In 1907 the mortality had decreased to 13.7.

Boston had in 1886 a mortality of about 40, in 1907 it was 18.5.

TABLE 6.—*Mortality from consumption at Boston.*



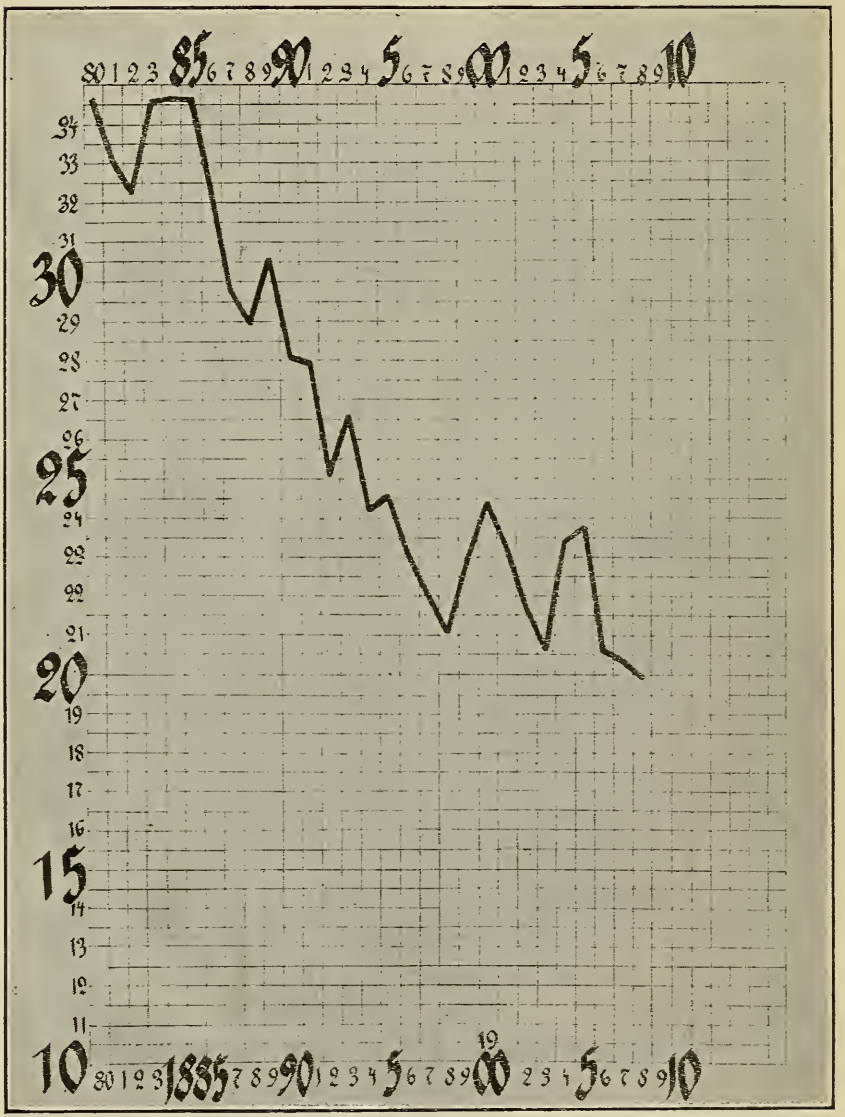
These figures are still more significant if we compare them with those of cities which are exposed to conditions similar to those of Hamburg and Boston. For this purpose we will compare Hamburg with Berlin (Table 7) and Boston with New York (Table 8).

The mortality curves of Hamburg and Boston descend at once and the decrease continues at a uniform rate, while in New York and especially in Berlin it has slackened for several years past.

The examples I have submitted, and which might easily be increased in number, show that there can be no question of a general,

regular, uniform decrease in mortality from consumption, and that we must therefore seek for other factors than those dependent on a spontaneous cause of decrease connected with the epidemiological course of the disease.

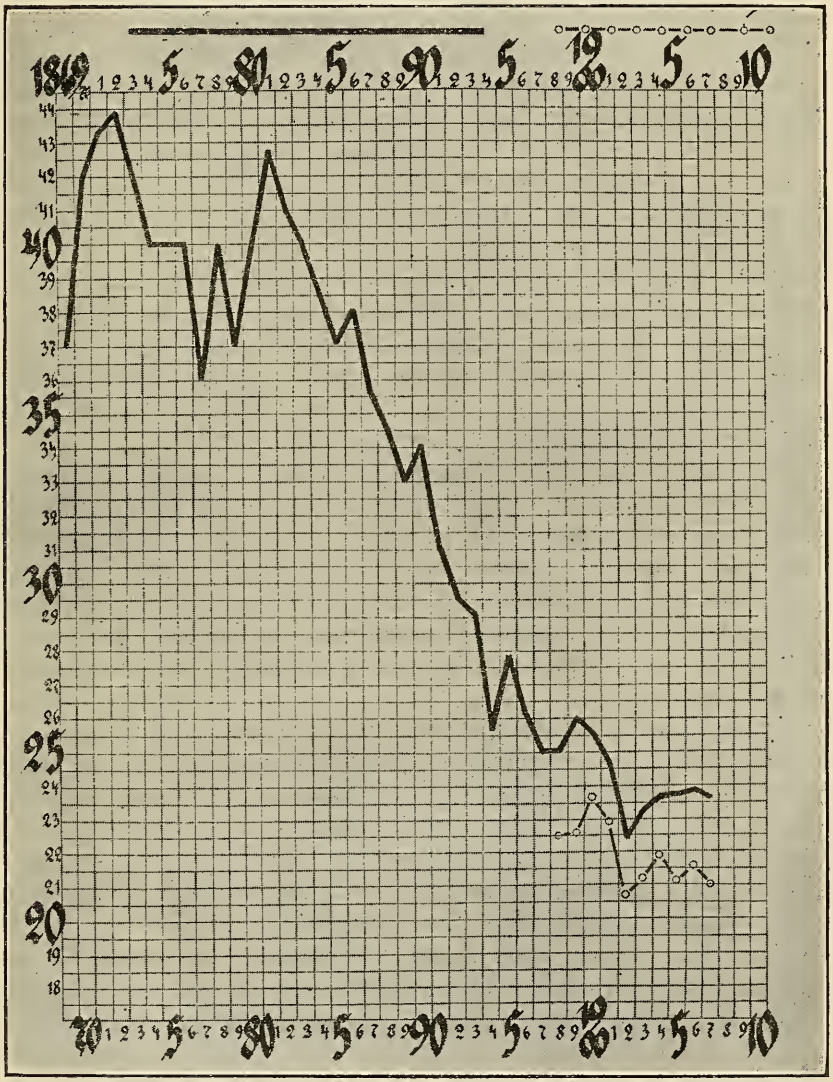
TABLE 7.—*Mortality from consumption at Berlin.*



It might be alleged that the virulence of tuberculosis has abated. But in reply to this it should be said first that the decrease in tuberculosis began quite suddenly, and after a few decenniums has reached, in many cases, 50 per cent and over. As the mortality from

consumption has been marked and often slowly increasing during 2,000 years it is not reasonable to suppose that it would decline all at once without any assignable cause. Besides, the decrease of virulence would first be manifested by an amelioration in single cases

TABLE 8.—*Mortality from consumption at New York.*



which would also more frequently terminate in recovery. But nothing of this kind occurs. It is indeed true that in modern times great advances have been made in the treatment of tuberculosis, and that we succeed, through the so-called hygienic-dietetic treatment and

especially by the specific treatment, in curing many cases. At present, however, only a comparatively small percentage of cases share this advantage, and for the cases not so treated we are unfortunately convinced again and again that pulmonary tuberculosis maintains the same deadly characters as formerly. Besides the decrease in consumption had already been going on for several years before the new methods of treatment had been widely disseminated.

The decrease in consumption has often been ascribed to the discovery of the tubercle bacillus. It has been said that by this, the infectious character of the disease was proved and that, in consequence of this, people became more cautious and avoided infection as much as possible, while previously physicians did not admit the infectiousness of consumption and the public at large followed them in this as a matter of course.

There is certainly much to be said for this argument. In any case it is very striking that, with a few exceptions, the decrease in consumption set in everywhere within a few years after that discovery. Yet the exceptions prove at once that this new-born fear of infection is not the only factor involved, although we must allow to it a certain influence which is by no means slight.

German authors have frequently claimed that social regulations, particularly insurance against illness, has had an effect upon the decrease of tuberculosis. To a certain extent this is undoubtedly true, particularly as regards present conditions in Germany; yet in most other countries, where such regulations have not yet been established, the decrease has been just as great and has been going on at the same time, so these regulations can not be with us the most weighty cause.

It would take me too long to enumerate and discuss all the attempts at explanation that have been made, and I will therefore confine myself in conclusion to those investigations of this question which appear to me to be of the most importance. These investigations were suggested by the striking fact that the death rate from tuberculosis shows great differences in the three countries belonging to Great Britain. In England and Scotland it is decreasing; in Ireland, on the contrary, it is slowly but evidently increasing. Newsholme, the well-known medical statistician, has endeavored to find the prime cause of this. With the greatest thoroughness he has examined all the factors in the question, chiefly lodging, food, conditions of service, care of the sick, emigration, and has finally become convinced that for Ireland the method of caring for the sick is the determining factor. While in England and Scotland phthisical charity patients are committed to isolated institutions, in Ireland they are supported without being required to place themselves in an institution; they therefore remain in their own lodgings and con-

tinue to spread infection about them. Newsholme endeavors also to prove that in Norway, too, the mortality from consumption is on the increase because insufficient care is taken for the placing of phthisical patients in hospitals. I might remark here that in Norway this defect has already been recognized and care has been taken to remedy it by founding special hospitals for consumptives. It appears that on account of this precaution the mortality curve in quite recent years no longer ascends. Newsholme says further that the very high mortality in Paris results from the insufficient hospital facilities, in consequence of which patients are not kept in long enough to insure protection of others against infection.

With reference to this I entirely agree with Newsholme that a commitment to hospital for as long a time and with as careful attention as possible is the most effective means of preventing infection and thereby the spread of consumption. My experience also shows that wherever consumptives are kept in sufficient numbers in hospitals there consumption is most diminished, and vice versa. It is also apparent that in no way can the danger of infection, which attends every phthisical patient, be so successfully combated as by isolation in a hospital. The value of hospital isolation is shown in a striking manner by such treatment of leprosy, as by its means we have attacked that disease with good results.

Besides this factor there is still a second one that plays a very important part. This is the housing of patients. The more contracted this is—the more lack there is of light and air—the more is infection favored. By many authors poverty and density of population have been mentioned as having a decided effect on the frequency of phthisis, and quite correctly so; but, in truth, this is caused by the defective and too small dwellings in which, through poverty and the increased density of population, people are forced to live. I might even go a step further and say that it is not so much the contracted character of the dwellings as a whole as the condition of the sleeping rooms that favors infection. Even in a spacious dwelling, in itself hygienic, the danger of infection may become very great if the inhabitants crowd together at night in a small sleeping room. It is certainly not an accident that with us the highest mortality from consumption is not found in the poor regions of the eastern provinces, but in the relatively prosperous and amply cultivated regions along the coast of the North Sea, where from olden times the evil custom has prevailed of using for sleeping rooms small, cell-like apartments built in the wall, the so-called cubbies (Butzen), which are shut up at night, and that in the northern parts of Sweden, with a climate that is notoriously healthy, the highest death rate for consumption occurs where people also sleep in closets quite similar to the cubbies of Frisia.

The striking fact that with us the cities often have a lower consumption death rate than does the surrounding country is apparently due partly to the want of hospitals and partly to the bad habits of the rural inhabitants, in that they, even when they have at their disposal several living rooms, select the meanest and smallest for a sleeping room. As an example of the distinction between city and country, the following statistics for certain Prussian provinces may serve (Table 9):

TABLE 9.—*Mortality from pulmonary consumption per 10,000 inhabitants.*

[After Hirsch, Historico-Geographic Pathology.]

Province.	In the city.	In the country.
Marienwerder	25.4	13.5
Danzig	23.9	14.1
Königsberg	24.9	15.5
Bromberg	31.3	18.5
Erfurt	26.9	27.0
Breslau	37.3	27.5
Hannover	33.8	44.4
Osnabrück	48.7	52.2
Cologne	47.6	53.4

But in cities, also, housing conditions are poor. There are numerous dwellings that consist of a single room, in which families, often with several children, live, cook, and sleep, often in a single bed. According to Rubner there are in Hamburg, Berlin, and Breslau 10 to 14 per cent of overcrowded dwellings, if we consider as such a room with but one window housing more than 5 persons.

Kayserling has estimated that, of the phthisical patients who die in their own rooms 40.6 per cent inhabit but one room, 41.7 per cent but two rooms; that in Berlin, during three years, 8,229 persons were exposed to the greatest danger of infection because of consumptives dying in one-room dwellings. It is well known that consumptives in the last stages of the disease, when they are helpless and expectorate sputum crowded with tubercle bacilli, are especially liable to spread infection.

If we adhere to the view that the most effective protection against infection is the isolation of consumptives in hospitals, and then reflect further that the number of such adult persons for which, on account of tuberculous disease, hospital treatment is necessary, amounts in the German Empire to from 150,000 to 200,000 annually, and that it is quite impossible to place these all in hospitals, nothing else remains but to isolate the greater part of them in their own dwellings. If it were possible to assign to each patient a separate sleeping room, this might be to some extent effected; but how can it be done if the entire dwelling consists of only a single room?

These considerations show that the decrease in consumption in recent times depends upon various factors, of which the two most important ones are the care of those affected by isolating them in hospitals and the improvement of housing conditions, especially as regards the sleeping rooms.

It is apparent from this that vast obstacles have yet to be overcome before we can succeed in reducing still lower the mortality from consumption, and finally reach a level which will possibly be below the lowest existing at the present time, namely, 7 per 10,000 persons.

We are now enabled to realize the great benefit that accrues from having an exact knowledge of the statistics of mortality from consumption in countries and cities. The mortality curve informs us at once whether the conditions are favorable or unfavorable, whether the mortality is decreasing and the measures taken are still effective, or whether improvements, supplementary regulations, etc., should be instituted. So in Norway the course of the consumption curve induced the authorities to take in hand the building of hospitals, and thus cause it to descend.

New York resolved, as soon as it was shown that the curve began to flatten and show greater variations, to take more care of the sick and to increase the number of beds assigned to consumptives from 2,500 to 5,000. In Berlin, for the same reason, there was erected a special hospital for pulmonary consumptives, with 1,000 beds.

It is very desirable that exact mortality statistics should be everywhere obtained and that studies of the same should be extended to smaller and smaller districts, so as to ascertain more fully the conditions that control the development of tuberculosis, especially in the case of small hamlets and country districts, and thereby to relieve them.

In our own country statistics are already developed far enough to enable us to scan the death rate from consumption in single districts. I have here the record of mortality in two departments, which exemplifies in a striking manner the interesting problems that result from a comparison between different districts. (Table 10.)

TABLE 10.—*Deaths from tuberculosis in 1907 per 10,000 inhabitants.*

Allenstein department (10.33):	
Osterode	7.2
Johannisburg	7.7
Sensburg	8.5
Neidenburg	9.5
Rossel	10.0
Ortelsburg	11.0
Lyck	11.5
Lötzen	11.5
Allenstein	13.0

Osnabrück department (23.34):

Osnabrück (country)	15.0
Iburg	17.0
Osnabrück (city)	18.0
Meppen	22.8
Melle	24.0
Aschendorf	24.0
Grafschaft Bentheim	25.75
Bersenbrück	28.0
Lingen	30.0
Wittlage	30.0
Hümmling	35.0

For an effective campaign against tuberculosis it would be necessary to go still further and divide each district into smaller areas, each of which should be specially investigated and provided with detention houses or other devices for combating the disease.

The statistics of mortality and the epidemiological researches connected therewith constitute an important feature of the measures by which tuberculosis is to be combated.